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Piloted Driving
Virginia Unmanned Systems Commission
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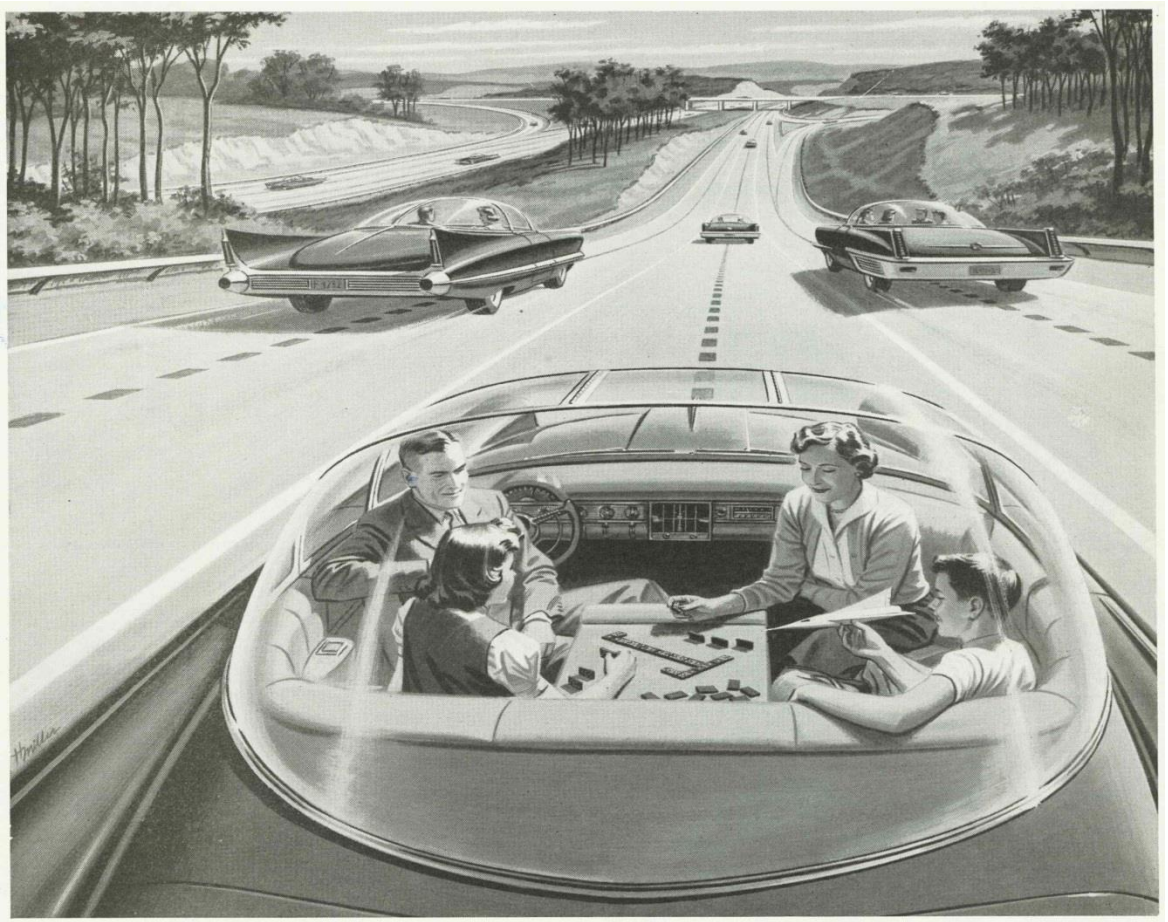
Audi BENTLEY BUGATTI LAMBORGHINI VW CREDIT, INC.

Fascination with Automated Driving



ELECTRICITY MAY BE THE DRIVER. One day your car may speed along an electric super-highway, its speed and steering automatically controlled by electronic devices embedded in the road. Travel will be more enjoyable. Highways will be made safe—by electricity! No traffic jams . . . no collisions . . . no driver fatigue.

Modern Day Futuristic Vehicle

Current Competitor Automated Driving Systems

HOW DID WE GET HERE?

Audi's "*Jack*" Piloted Drive Vehicle

VW & Audi Pioneers in AV Technology

- Volkswagen's "Stanley" – Winner of the 2nd DARPA Grand Challenge 2005 (There was no winner of the 1st DARPA Grand Challenge).
- In Smithsonian
- Note cameras and antennae

Volkswagen's "Junior" Passat Wagon Placed 2nd out of 85 2007 DARPA Urban Challenge

Audi & Stanford University's "Shelley" 2010

First to climb 14,000 foot summit of Pike's Peak completely unmanned (2010)

Nearly 13 miles with 156 precarious turns without stopping!

Other Audi "Firsts"

"California's First Autonomous Driving Permits Go to Audi…"
Car & Driver September 23, 2014

Audi claimed the fastest fully-automated driving speed on a race course at

149 mph

Hockenhiem, Germany - 2014

Industry Creates Standards
Driving automation vs. other kinds of automation

Focused on automating driving task

SAE taxonomy of driving automation (J3016)

- classification system with 6 levels (0-5)
- supporting terms and definitions.

Does not apply to:

- automated components (windows, doors, sunroofs, etc.)
- warning systems (forward collision, blind spot, back-up, etc.)
- emergency intervention systems (anti-lock brake system, electronic stability control, automated emergency braking, etc.)

Why terms, definitions and levels matter

Avoid confusion and facilitate discussion

- Same words used to mean different things (conferences, media reports, advertising…)
- Consensus taxonomy and definitions save time and effort (“short-hand”)
- Categorize technology based on functional attributes

Support legal and policy discussion and development

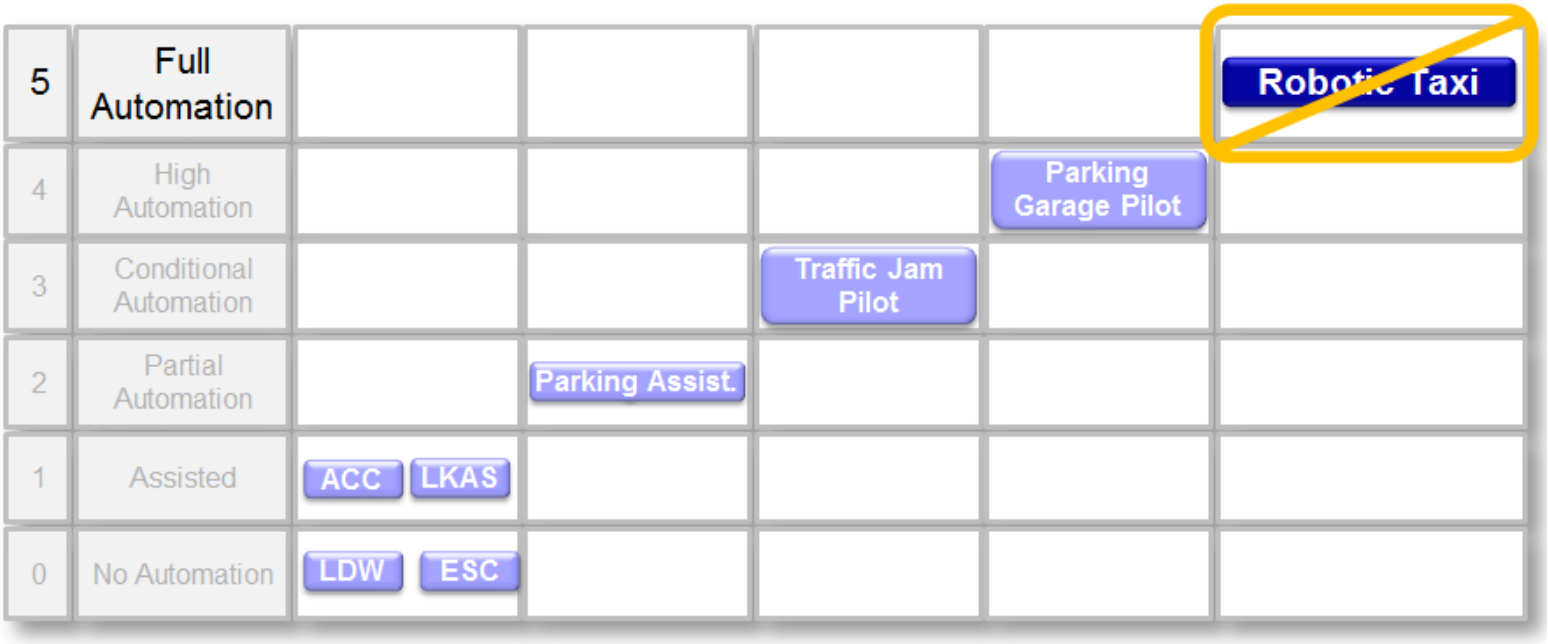
- What’s in-/out-of-scope
- Level-appropriate requirements (if any)
- Clarify driver’s role in proper usage

Summary table describing levels (SAE J3016)

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

To purchase (~$70 for non-members): http://standards.sae.org/j3016_201401/
Free one-page summary: http://articles.sae.org/13573/

Level 5 Robotic Taxi



Eventually, but not soon!

Analyzing some recent company claims

GM SuperCruise: "General Motors…will introduce a Cadillac model in two years that **can travel on the highway without the driver holding the steering wheel or putting a foot on a pedal**"

- = SAE **Level 2**

Tesla Autopilot: "Tesla is also adding **semi-autonomous driving features**…that will allow owners to **leave some of the driving to the car's on-board computers**…These systems use sensors and cameras to help **keep the car in its lane on highways while maintaining a safe following distance**…The car will be able to **automatically change lanes…when the driver uses the turn signal**…"

- = SAE **Level 2**

Mercedes-Benz Traffic Jam Assist: "**In congested traffic**, a driver can **let the car steer, brake and accelerate itself…**"

- = SAE **Level 2**

Google's latest announcement: "…a dome-shaped two-seater with a **top speed of 25 mph**, is entirely computer-controlled, **lacking even a steering wheel**."

- = SAE **Level 4**

On the question of regulation

- Vehicle manufacturers and their suppliers have developed every safety innovation ever deployed on cars and trucks
  - Safety benefits quantified, benchmarking, customer acceptance…(~ a decade)
  - Regulation (*minimum* safety performance standards) always follow deployment
- Establishing minimum safety performance requirements before a technology has been deployed and proven in use is unprecedented (for good reason!)
  - High risk of stifling innovation
  - Certainty of sub-optimizing technology development
  - Cost
- Special considerations
  - Minimum safety performance requirements vs. ‘do no harm’
  - Established companies vs. start-ups and small businesses
  - Federal vs. State regulatory domains

What States Can Do NOW

Standardize Signage following National and International Standards

Maintain Highway signs
Must be clearly visible to vehicle

Educate Law Enforcement on Automated Driving Technologies

What States Can Do NOW!

Maintain Clear Lane Striping

Eliminate Use of Botts Dots

CONCLUSION

- Fascination with Automated Driving Systems continues today
- Audi and VW are pioneers and leaders in Autonomous Driving Technology
- Standardized terminology matters (SAE definitions)
- Levels of driving automation matter, because they:
  - provide meaningful distinctions in functional terms
  - clarify roles (driver, driving automation system or ADS, base vehicle)
  - provide a framework for policy development
- Near term benefits largely comfort, convenience, cost; longer term benefits for safety, mobility, environment
- Premature laws and regulations threaten pace and extent of deployment if not carefully designed to minimize negative effects (restricting innovation, design sub-optimization, consumer disincentives, unnecessary cost…)

CONCLUSION (continued)

- States can facilitate ADS deployment by:
  - Avoiding new burdens on drivers (special license and/or registration reqts)
  - Preparing legal environment for deployment
    - Exempting persons in the driver's seat of ADS-equipped vehicles (Levels 3-5) operating in automated driving mode from anti-distraction laws
    - Maintaining/improving road markings and condition
    - Updating affected personnel and processes (police, courts, driver training/testing…)